Removal of Transformation Errors by Quarterion In Multi View Image Registration

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Abstract—**This method is based upon the image registration process and the application is when the text which is to be identified is behind the mesh which works as a hurdle. We know that the mesh as hurdle can be made less irritating by either moving the camera or the source itself. The method uses Radon Transform for extracting the mesh lines and capturing the position of the mesh lines. The final process of filling the deformed image is through the registration. The method is adaptive to movement in any direction. The transformation errors are removed by the Quarterions. It was tested on a number of images [200] approximately and gave excellent results.**

Index Terms—**Image Registration, Image Processing, Image in motion, Quarterions.**

I. INTRODUCTION

In computer vision, set of data acquired by sampling the same scene or object at different times, or from different perspectives, will be in different coordinate systems. Image registration is the process of transforming the different sets of data into one coordinate system. Registration is necessary in order to be able to compare or integrate the data obtained from different measurements. The Multi View Image Registration technique uses images of an object taken from different views called modalities. Many interesting and useful approaches to the multiview registration problem have been proposed in the recent past. Chen and Medioni, and Masuda and Yokoya both incrementally register views against a growing global union of view points [3], [6]… Bergevin et al. place all views into a global frame of reference, and then repeatedly select a view and register it against all others [2]. Stoddart and Hilton find pairwise correspondences between points in all views, and then iteratively minimize correspondence errors over all views using a descent algorithm [11]. This basic technique is extended using a multiresolution framework, surface normal processing, and boundary point processing by Neugebauer [7] and Eggert et al. [4]. Williams and Bennamoun suggested a further refinement by including individual covariance weights for each point [12]. Sawhney et al. and Shum and Szeliski perform the global alignment of two dimensional mosaics by nonlinear minimization of distance between point correspondences [8], [10]. Gregory, Lee, and David address the problem of large-scale multiview registration of range images captured from unknown viewing directions [9].

Benjemaa and Schmitt propose a nonlinear solution based on the quaternion representation [1]. Their formulation is a multiview extension of the pairwise solution proposed by Horn [5] using distance between pairwise correspondences as the optimization criterion. Donghun Lee, Jihun Park [15] presents a quaternion-based method to estimate the camera parameters in a single video stream to interpolate 3D trajectory of the moving camera with camera parameters. Jihun Park [16] determining camera parameters for three dimensional scene reconstruction given an image with three known points on a single plane on the image . Robert Bergevin, Marc Soucy, Hewe Gagnon, and Denis Laurendeau [17] present an algorithm that reduces the level of the registration errors between all pairs in a set of range views. Chang Yuan, Ge´rard Medioni, Jinman Kang, and Isaac Cohen [18] present a method for detecting motion regions in video sequences observed by a moving camera in the presence of a strong parallax due to static 3D structures. The proposed method classifies each image pixel into planar background, parallax, or motion regions by sequentially applying 2D planar homographies, the epipolar constraint, and a novel geometric constraint called the "structure consistency constraint." Jung-Young Son, Vladimir V. Saveljev, Jai-Soon Kim, Kae-Dal Kwack, and Sung-Kyu Kim [19] Proposed a method based on 4*4 homogeneous matrices which can predict distortions in the perceived image in projection-type multiview 3-D imaging systems. Jiangbo Lu, Hua Cai, Jian-Guang Lou, and Jiang Li [20] propose a DE technique to accelerate the disparity search by employing epipolar geometry. Lou, Hua, and Jiang present the system architecture for real-time capturing, processing, and interactive delivery of multi-view video.

In this paper, the proposed algorithm is a practical approach for solving the global registration parameters using the relative motion between view pairs as the error criterion. This criterion does not require linearization and, therefore, can be used even when the accumulated rotational error is large. Furthermore, this criterion does not require point correspondences and can therefore be used together with robot odometry or any registration method. These different modalities are then analyzed and the information obtained is fused to form a coherent composition called multimodal image.

This paper addresses the problem of large scale multiview

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registration of range images captured from unknown viewing directions. The global error distribution method described in can be used together with any pair wise registration algorithm to perform globally consistent multi view range image registration. The paper is concerned with the existence of hindrance in the view of an object, like when a mesh appears in between the camera and the object thus making it partially unrecognizable. The hindrance in the view or the mesh can be considered as a kind of periodic noise and the technique multi view image registration has been used for the solution of this problem. The application of image registration is useful if and only if either mesh, camera or the object is moving relative to other two i.e. each frame in unique in terms of information with respect to the previous and the next frame. So the three possible situations are:

(i) Mesh and the object are stationary but camera is in motion.

(ii) Camera and the object are stationary but mesh is in motion

(iii) Camera and mesh are stationary but object is in motion.

Here, the first situation has been considered in which mesh and the object are stationary but the camera is moving in different directions i.e. at different angles to collect the necessary information about the object which is hidden in the view at some angle but is accessible at a different angle. The movie is then converted into frames. One frame is taken as a reference frame and the rest are target frames. Radon transform to detect hindrance in the view i.e. mesh in the reference frame and the fusion technique, Pixel based fusion to fill new information collected from target frames in place of hindrance. The method is an extract of the natural registration process and hence the approach is proven. The paper is arranged as follows: Section-2 gives a briefing of the method followed. Section-3 explains the pre-processing, which in this case is the separation of the frames and the removal of the wired mesh. Section-4 explains feature-extraction and the Section-5 explains the registration algorithm. The next Section-6 gives the results obtained followed by the conclusions in Section-7.

II. MULTIVIEW REGISTRATION PROCESS

Multiview video or free-viewpoint video is an exciting application, because it enables users to watch a static or dynamic scene from different viewing angles. Generally, to provide a smooth multi-perspective viewing experience, content producers need to capture a distinct scene with ideal quality from multiple camera positions, such as the multiview camera setup shown in Fig. 1, where a multiview image set is produced by steadily moving a single video camera around a scene of interest along a predefined capture trajectory The simultaneous multiple video streams from multiview cameras are referred to as multiview video. A multiview video sequence can be regarded as a temporal sequence of special-visual-effect snapshots, captured from different viewpoints at multiple times. Multiview image set can be generated by multiple cameras which are positioned at different angles to

capture the scene from different angles. Multiview image set can also be generated when the camera is stationary whereas the target image is moving. Here in this paper we consider that a single camera is moving while the target is stationary.
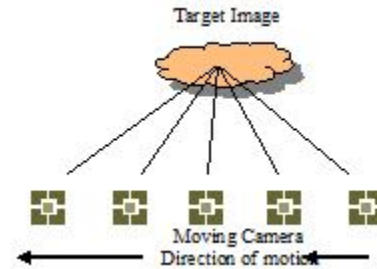

Figure 1: Multiview Detection Scheme

A. Error due to Transformations

In Figs. A, the x and y axes are shown as correctly aligned and mutually perpendicular. In Figure 2 the x1 and y1 pair of axes are shown as rotated through an angle α relative to the x, y pair. The x1, and y1 pair are still perpendicular, but as a coordinate frame it is not correctly aligned. This is called drift or rotational error.
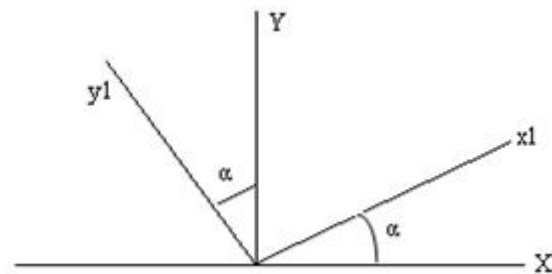

Figure 2: Rotation of X and Y axes

In addition to the drift or rotational error, there is a second kind of possible distortion of a coordinate frame called scale error. Pure scale error exists when the x1 and y1 axes, respectively, coincide with the x and y axes, but the vectors which are supposed to be unit vectors fail to have unit length.

B. Rotational Error

D=

$$\begin{vmatrix} qw^2 + i\,qx^2 - j\,qy^2 - k\,qz^2 & 2 \cdot qx \cdot qy - 2 \cdot qz \cdot qw & 2 \cdot qx \cdot qz + 2 \cdot qy \cdot qw \\ 2 \cdot qx \cdot qy + 2 \cdot qz \cdot qw & qw^2 - i\,qx^2 + j\,qy^2 - k\,qz^2 & 2 \cdot qy \cdot qz - 2 \cdot qx \cdot qw \\ 2 \cdot X \cdot qz - 2 \cdot qy \cdot qw & 2 \cdot qy \cdot qz + 2 \cdot qx \cdot qw & qw^2 - i\,qx^2 - j\,qy^2 + k\,qz^2 \end{vmatrix}$$

(1)

Let l,m and n be the components of angular velocity as functions of time. Then q(t) is found as a solution of the system of differential equations

$$\begin{vmatrix} qw' \\ qx' \\ qy' \\ qz' \end{vmatrix} = 1/2 \begin{vmatrix} 0 & -l & -m & -n \\ l & 0 & n & -m \\ m & -n & 0 & l \\ n & m & -l & 0 \end{vmatrix} \begin{vmatrix} qw \\ qx \\ qy \\ qz \end{vmatrix}$$

(2)

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Let's denote the square matrix above as W then we can rewrite

$$q' = \frac{1}{2}Wq \qquad (3)$$

Let the transition matrix corresponding this be Z (t, to). Then we may represent the solution of (2) as

$$q(t) = Z(t, to)q0 \qquad (4)$$

Where q0 represents the initial condition quaternion at time t0. Now suppose that f represents an additive noise perturbation to (4) due to error. Let the corresponding perturbed solution be p(t). We will assume that the initial value, p(t0), is likewise equal to q0. The perturbed differential equation is

$$p' = (1/2)Wp + f \qquad (5)$$

The solution to this equation is

$$p(t) = Z(t, t0)q0 + \int_{t0}^{t} Z(t,\tau)f(\tau)d\tau \qquad (6)$$

Denote the integral term in (6) by r (t). Comparing (4) and (6)

$$p(t) = q(t) + r(t). \qquad (7)$$

By definition,

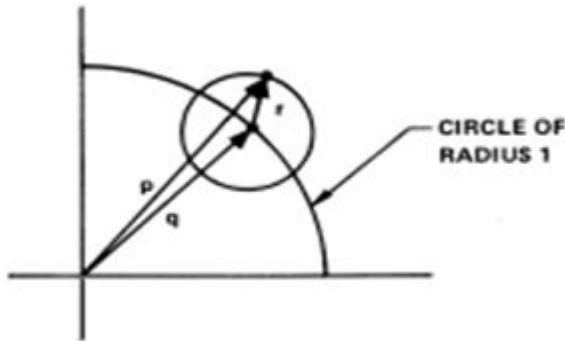$$\| q \| = 1 \qquad (8)$$

Figure 3: Quarterion Perturbation

A geometrical analog in two dimensions for the quaternion perturbation is shown in Figure 3. The quaternion q is always confined to the circumference of a circle of radius 1. The perturbation r may be in any direction with equal likelihood. Given only the vector p, without being able to make reference to q, the only way we can tell that a perturbation has occurred will be from the fact that

$$\| q \| \neq 1 \qquad (9)$$

Since there is no way we can estimate the angular deviation of p relative to q, the only realistic correction we can make is to rescale p back to the circumference of the unit circle in such a way that the angular deviation is equally likely to be positive or negative. Therefore, introduce the corrected quaternion p* obtained by

$$p^*(t) = p(t)/\|p(t) \qquad (10)$$

$$p(t) [p12(t) + p22(t) + p32(t) + p42(t)]1/2 \qquad (11)$$

Since the true quaternion q is not available to us, use p* in place of q in (1) in order to compute D. Now construct a 4*4 matrix S having the quaternion components as its elements

$$S = \begin{matrix} wq & xq & yq & zq \\ -xq & wq & zq & -yq \\ -yq & -zq & wq & xq \\ -zq & yq & xq & Wq \end{matrix} \qquad (12)$$

Also introduce a related matrix T as

$$T = \begin{matrix} wq & -xq & yq & -zq \\ xq & wq & zq & -yq \\ yq & -zq & wq & xq \\ zq & yq & xq & wq \end{matrix} \qquad (13)$$

Considering D as an orthogonal direction cosine matrix, the transformation matrix in four dimensional spaces can be written as

$$A_4 = \begin{matrix} 1 & 0_{1*3} \\ 0_{3*1} & D \end{matrix} \qquad (14)$$

$$A_4 = \begin{matrix} 1 & 0 & 0 & 0 \\ 0 & d11 & d12 & d13 \\ 0 & d21 & d22 & d23 \\ 0 & d31 & d32 & d33 \end{matrix} \qquad (15)$$

These matrices commute. Further by quaternion properties we can say

$$A = ST = TS \qquad (16)$$

Now apply the above procedure to an error analysis. By (7), the effect of computational errors will be that the matrixes S and T are formed from the elements of p rather than q. Denote the results as Sp and Tp. Further, denote the matrixes formed in the same way using the components of r by Sr and Tr.

$$S_r = \begin{matrix} r1 & r2 & r3 & r4 \\ -r2 & r1 & r4 & -r3 \\ -r3 & -r4 & r1 & r2 \\ -r4 & r3 & -r2 & r1 \end{matrix} \qquad (17)$$

$$T_r = \begin{matrix} r1 & -r2 & -r3 & -r4 \\ r2 & r1 & r4 & -r3 \\ r3 & -r4 & r1 & r2 \\ r4 & r3 & -r2 & r1 \end{matrix} \qquad (18)$$

Then considering (7)

$$\begin{matrix} S_p = S + S_r \\ T_p = T + T_r \end{matrix} \qquad (19)$$

From (15)

$$S_p T_p = (S+S_r)(T+T_r) = ST + S_r T + ST_r + S_r T_r \qquad (20)$$

Neglecting the term $S_r T_r$ Direct computation will reveal that the pair of matrixes S_r and T, as well as the pair of matrixes S and T_r, actually commute. Rearranging (20)

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$$S_p T_p = ST(I_4 + S'S_r + T'T_r) \tag{21}$$

Here S' and T' are the transpose of matrixes S and T. Let the perturbed version of A be called B. Then equation (21) may be written as

$$B_4 = A_4 (I_4 + H_4) \tag{22}$$

Here I_4 is a 4*4 identity matrix and

$$H_4 = S'S_r + T'T_r \tag{23}$$

the matrix H4 may be split into its symmetric part $\backslash_4$ and its anti symmetric part U_4:

$$\hat{S}_4 = \frac{1}{2}(H_4 + H'_4) \tag{24}$$

$$U_4 = (H_4 - H'_4) \tag{25}$$

The matrix $\backslash_4$ represents the scale and skew errors, and the matrix U_4 represents the drift errors, which have crept into the computation of rotation via quaternion.

Reconsidering the equation (5). The sign of the perturbation vector f could, in fact, may be plus or minus.

Therefore, the sign of r in (7) could equally likely be plus or minus. Similarly the sign of H4 in (23) could equally likely be plus or minus. Hence, the algebraic signs associated with \4 and U4 may be plus or minus. Substituting (12), (13) and (17), (18) into equation (23) and the result then putting in (24) one finds that

$$\hat{S} = 2(q.wr_1 + q.xr_2 + q.yr_3 + q.zr_4) I_4 \tag{26}$$

Therefore, if the elements of \4 are positive, it means, referring back to Fig. B, that the tip of r lies outside the unit circle. Similarly, if \4 has negative elements, it means that the tip of r lies within the unit circle. At the same time, the associated rotational error could equally likely be in either direction.

We can now readily see that our proposed correctional procedure, represented by (10), will have the effect of reducing \4 to zero. Furthermore, while this procedure will not drive U4 to zero, it will, in fact, almost always reduce the norm of U4. At worst, in a few situations (i.e., when IIPII = 1 to begin with), the correctional procedure will have no effect on U4.

III. THE PRE-PROCESSING

The first step is to extract the frames from the video. One of these frames is chosen to be the reference frame and the rest are target frames. Since the images have been taken from a single optical device, they are classified as single-modality images. The reference image is processed further so that hindrance is removed from the view and the target images are registered into the reference image to make the object recognizable. Following is the method followed:

Algorithm 1: Extraction of frames

1. Read in the video file
2. Determine the suitable number of frames required per second
3. Extract the frames from the video clip
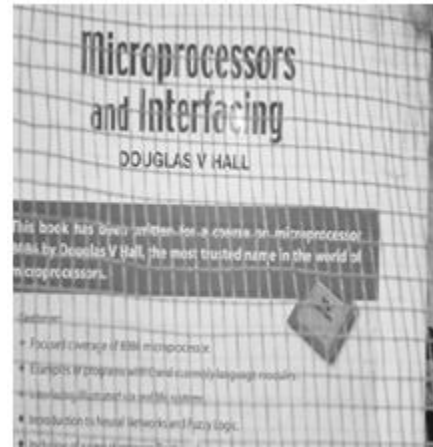4. Choose an appropriate reference image from these frames
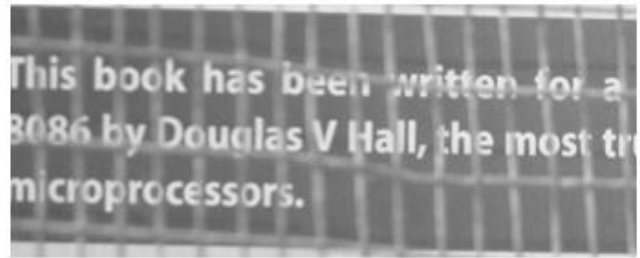

Figure 4(a): reference frame (original)

Figure 4(b): Target frame (original)

Let the captured views lie within coordinate frames V1,...,Vn, where two frames Vi and Vj are related by the rotation and translation (Ri,j, ti,j). A point pj in frame Vj can be described in frame Vi according to the change of coordinates

$$pi = Ri,j \, pj + ti,j \tag{27}$$

In practice, the change of coordinates between neighboring views will be found using odometery or a pair wise registration procedure [1]. We shall call such changes of coordinates, measurements.

The next step is to detect and remove the mesh lines. In order to determine the sections of the pictures to be fused, the exact coordinates of the pixels corresponding to the noise in the picture should be known. The noise in the reference image is in the form of mesh which is nothing but an array of horizontal and vertical lines. Since, the radon transformation is a very powerful technique for the detection of straight lines; it has been used for the purpose of mesh detection. The detection of the mesh lines is achieved with the Algorithm-2. In this algorithm

1. First the image is read as a three dimensional matrix

with each element representing some intensity values Corresponding to three colors red, green and blue (RGB image).

2. Before applying radon transform, the image is converted into grayscale image which is a two dimensional image with intensity values varying from 0 to 255, 0 corresponding to black and 255 corresponding to white.

Algorithm 2: Mesh Detection

Given: frames
1. for all available frames, do
2.   Read in the grayscale image IMG
3.   RADON←Radon_Transform(IMG)
4.   for ANGLE← (1 to 3) & (88 to 92) & (178 to 180), do

        [to consider only the vertical and horizontal mesh lines]
5.   If RADON[I, ANGLE] >= Mean(Peak_values)
6. SORTED_RADON[I, ANGLE]←RADON(I, ANGLE)
7.   end if
8.   end for
9.
INV_RADON←inverse_Radon_Transform(SORTED_RADON)
10.
[WIDTH,START_X,START_Y]←Mesh_Stats(INV_RADON)
11.   MAPPED_IMG←
Mapping(IMG,HOR_GAP,VERT_GAP,

START_X,START_Y,WIDTH)
12. End for

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3. Radon transform [14] is applied on the grayscale image to detect the lines representing the mesh. Figure-6(a) shows the radon   transform for figure-5. Figure-6(b) shows the sorted out peak values from the Radon transform that correspond to the straight of the mesh.
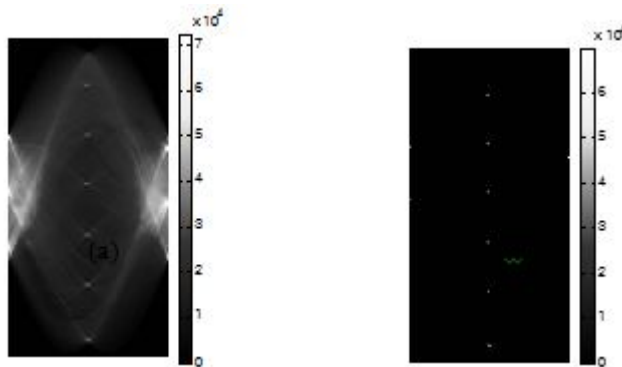

Figure-5: Randon Transform of Grey scale image

The Radon transform gives projection of the image intensity along a radial line oriented at a specific angle varying

form 00 to 1800. Radon transform provides with the radial coordinates of the lines corresponding to each projection and corresponding intensity values.

The Radon transform for a set of parameters (rho, theta) is the line integral through the image g(x, y), where the line is positioned corresponding to the value of (rho, theta). The delta () is the Dirac delta function which is infinite for argument 0 and zero for all other arguments (it integrates to one) [13].

Equation (28) and (29) represent the above expressions.

$$\breve{g}(\rho,\theta) = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} g(x,y)\delta(\rho - x\cos\theta - y\sin\theta)\, dx\, dy$$

(28)

and the identical expression

$$\breve{g}(\rho,\theta) = \int_{-\infty}^{\infty} g(\rho\cos\theta - s\sin\theta, \rho\sin\theta + s\cos\theta)\, ds$$

(29)

The very strong property of the Radon transform is the ability to extract lines (curves in general) from very noisy images as shown below in Figure-6.
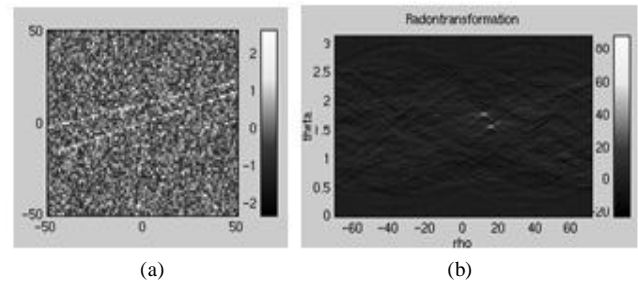

(a)   (b)

Figure-6 :Sorted peak from Randon Transform

From the Radon transform, shown in Figure-7, it can be seen that crossing lines makes no problem.
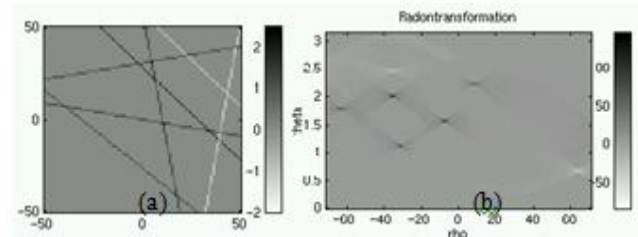

Figure-7: Removal of lines by Randon Transformation

The peak points of intensity values correspond to straight lines in the reference image. A simple thresholding algorithm is applied to pick out the line parameters.

4. Inverse radon transform is applied to the line parameters obtained in the previous step which give lines representing the mesh. The inverse radon transform inverts the radon transform, and can therefore be used to reconstruct images from the projection data. It uses the radial coordinates of the line and the angles of projection to get the lines in the image. Radon uses parallel-beam projections to reconstruct the image. In parallel-beam geometry, each projection is formed by combining a set of line integrals through an image at a specific angle. As the number of projections i.e. length of theta increase, the reconstructed image is more accurate so

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the length of theta vector has been taken from 00 to 1800 and theta must increase monotonically with a constant increment of 10.

5. These lines are further used to map the mesh or the noise and find the total area along with the coordinates of pixels where the information is to be filled during fusion.

IV. FEATURE EXTRACTION

In order to obtain the new information to be filled following parameters should be known.

1. Quantization of Information In Successive Frames

The amount of the information changes in successive frames should not exceed the width of mesh i.e. should not change abruptly, because if it does the embedded information will overlap the previous information and the final image will be distorted. So the determination of optimized number of frames captured per second is very important before they are processed.

2. Direction of Change in the Information

Since a camera has been used for the movie of the object, the camera can be considered as a point that can move randomly in all possible directions at any possible angle in the space but only in a fixed plane. The direction of movement of camera can be classified in two major categories.

ii.　　　Perfect horizontal or vertical motion.

iii.　　　The inclined motion.

The direction vector is calculated by dividing the information in between the mesh of the reference image into 4, 9 or 16 equal parts depending upon the need of accuracy or computational time. More is the number of parts, higher is the accuracy　but more will be the computational time. So, need is to find out the optimized value, which comes out to be 9. The information from the next frame from the same coordinates is calculated and divided into 9 equal parts. Now the correlation of each corresponding part is calculated. The part which has undergone maximum change gives the lowest value for correlation. Thus the minimum value of correlation gives an approximate value of direction vector i.e. movement of camera.　The direction vectors 2, 4, 6 and 8 correspond to perfect horizontal and vertical motion and 1, 3, 7 and 9 designate the inclined motion respectively. (Figure-8 shows a single cell from the target frame Figure 4).

Figure 8:Single cell from the target frame Figure 4

3. Pixel positions of New Information

The registration process being implemented is feature-based registration so the features changed in the new frame with respect to the previous one have to be extracted before the fusion is done. The quantization determines the amount of features changed and direction vector determines the coordinates of new information i.e. the new information is specific for a particular detection vector and extraction of features is also divided into two categories:

i. First is when the information is changing linearly exactly horizontally or vertically. The new information is rectangular and can be easily detected by merely comparing the new frame with the previous one along each column.

ii. Second condition deals with the condition when the camera is moving at an inclination i.e. information enters into the frame diagonally. This time new information is not uniform and extraction is much more complicated and is drawn out by successively comparing the new frame with the older one along both rows and columns.

V. FUSION TECHNIQUE

The fusion technique being used is pixel based fusion and involves placement of information obtained from previous step in place of mesh. The coordinates of the mesh in the reference frame have already been determined like the previous step fusion also depends upon the direction vector

The new information is embedded into the reference frame which gives noise free information i.e. views of object without any kind of hindrance. . (Figure-9 shows the resultant image).

VI. THE REGISTRATION ALGORITHM

The Following Algorithm (Algorithm-3) is the one used to implement the multi view registration of the images
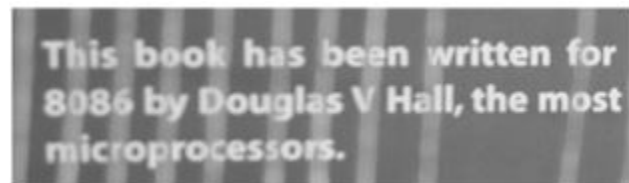

Figure 9:The Resultant Image

The purpose of the algorithm is to perform the pixel based fusion on a pair of frames. One is the reference frame called the base frame (BASE_IMG) and other is one of the target frames chosen for fusion from the video clip.

The basic approach taken is to first divide the whole picture into elementary rectangular cells/blocks of the mesh, determine the direction of motion, calculate the drift of the pixel positions to determine the picture section to be fused and finally fuse the calculated pixel positions.

The algorithm stated above reads in a base frame, BASE_IMG along with a target frame from the clip, NEXT_FRAME. BASE_IMG is then divided into the cells of the mesh. The same coordinates of division are then followed to divide NEXT_FRAME image. Next a loop is started that repeats the further processing on each of these cells. This processing involves, dividing corresponding cells of both the images into nine equal parts. The partitions obtained are then compared for both the images using the correlation. The partition pair with minimum value for correlation indicates

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Algorithm 3: Image Fusion

Given BASE_IMG, NEXT_FRAME
1.   Read in the actual reference image ORIGINAL_BASE
2.   Divide BASE_IMG into elementary rectangular mesh cells such
          that no part of the mesh lines is included
3.   Divide the NEXT_FRAME into cells with same coordinates as of
          the BASE_IMAGE cells
4.   for all cells in the BASE_IMG, do
5.   BASE_CELL←Current BASE_IMG cell
6.   NEXT_FRAME_CELL←Current NEXT_FRAME cell
7.   Divide both cells in 9 equal partitions
8.   for all corresponding partition pairs in both cells, do
9.   CORR_VAL[I]←correlation(BASE_PART,NEXT_PART)
10.   end for
11.   DIRECTION←Max(CORR_VAL[ ])
12.   H_DRIFT←Find_horizontal_drift(NEXT_FRAME_CELL)
13.   V_DRIFT←Find_vertical_drift(NEXT_FRAME_CELL)
14.   for Drifts in both orientations, do
15.   From the edge of cell, move DRIFT pixels away along the
          length of edge
16.   Fuse this calculated section of selected pixels from the
          NEXT_FRAME into BASE_IMG
17.   end for
18. end for

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the direction of the motion. After this, the Horizontal and vertical drifts of pixel positions from BASE_IMG to NEXT_FRAME are calculated in accordance with the direction of the motion. With these steps all the necessary data for fusion is available. This data gives the section of the image NEXT_FRAME to be fused with the BASE_IMG. Fusion is performed to fill up the mesh lines in BASE_IMG with the information extracted from the NEXT_FRAME that gives the resultant image free of noise i.e. the mesh.

VII. RESULTS AND DISCUSSION

This paper shows the practical implementation of the registration process that the human brain does automatically when some one looks at an object through the mesh and by moving the head or the mesh, he is able to recognize the object completely. The results from the applied method have been quite encouraging. The extent of the distortion in the results is observed to be sufficiently low. The data for the application were taken under the assumptions that the camera motion involved only horizontal and vertical translations without any rotations, that the motion is confined to a single plane and that the lighting conditions and background view do not change considerably. Although the rotational variances could be nullified by applying opposite rotational transformations on the extracted frames, the process was avoided in the samples for the sake of simplicity.

VIII. CONCLUSION

The method was tried on 200 images having wire mesh as on the fore ground. This method removed all of them. The method works very well till the background does not change but need modification for accommodating the change in the background. It has been realized that the background change due to shadow only disturbs the registration process. This can be overcome by re-registration process but it is time consuming. The application is new and the method is insensitive to any kind of skew occurring due to the movement of camera in unknown direction.

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